Neurocomputing ■ (■■■■) ■■■–■■■

Contents lists available at ScienceDirect

Neurocomputing

journal homepage: www.elsevier.com/locate/neucom

Local extrema co-occurrence pattern for color and texture image retrieval

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ARTICLE INFO

Article history:
Received 1 July 2014
Received in revised form
14 February 2015
Accepted 6 March 2015
Communicated by Xiaofei He

Keywords:
Local extrema co-occurrence pattern
Local extrema patterns
Gray level co-occurrence matrix
Corel database
MIT VisTex database
STex database

ABSTRACT

A real world problem of image retrieval and searching is considered in this paper. In modern generation, managing images from a large storage medium is not a straightforward job. Many researchers have worked on texture features, and produced diverse feature descriptors based on uniform, rotation invariant, edges and directional properties. However, most of them convert the relationship of the center pixel and the boundary pixel into a local pattern, and use histogram to represent the local pattern as a feature vector. In this work, we propose a new image retrieval technique; local extrema co-occurrence patterns (LECoP) using the HSV color space. HSV color space is used in this method to utilize the color, intensity and brightness of images. Local extrema patterns are applied to define the local information of image, and gray level co-occurrence matrix is used to obtain the co-occurrence of LEP map pixels. The local extrema co-occurrence pattern extracts the local directional information from local extrema pattern, and convert it into a well-mannered feature vector with use of gray level co-occurrence matrix. The presented method is tested on five standard databases called Corel, MIT VisTex and STex, in which Corel database includes Corel-1k, Corer-5k and Corel-10k databases. Also, this algorithm is compared with previous proposed methods, and results in terms of precision and recall are shown in this work.

1. Introduction

Content based image retrieval (CBIR) is a hybrid research area, which needs knowledge of both mathematics and computer science for an efficient image retrieval system. Image retrieval is based on image matching, and image matching is performed by feature matching. Image features may contain color information, textural distribution information, object shapes, object's spatial orientation, etc.

1.1. Motivation

The expansion of online and offline images in various areas, e.g., education, news, entertainment, etc. make retrieval of images both fascinating and important. Searching, browsing and retrieving images from a huge database are unrealistic and unsuitable problems. Text based image retrieval is a traditional searching method which deals with key words and metadata of the image. Next, content based image retrieval came in the scenario that handles genuine content of the image rather than metadata. Fast and efficient CBIR methods are the requirement of the system these days.

Many local patterns for image retrieval have been proposed by researchers, but most of the local patterns consider the frequency of each pattern in the image, and treat it as a feature descriptor using histogram. But frequency gives information, only regarding to the occurrence of the pattern alone, and it does not reveal any information regarding the mutual occurrence of patterns in the image. Mutual occurrence of patterns is considered in this work. Also, earlier works with local pattern have treated color information and texture pattern as individual features. In this work, texture feature of local pattern has been extracted using color space component not individually.

1.2. Related work

Texture and color analysis are the major fields in the image retrieval process. Texture is dependent on the local intensity of image, hence, statistical features and local neighborhood features are discovered for texture patterns. Another low level feature is color, and it is presented as distribution of intensity in different color channels, therefore color histogram, color correlogram, color coherence vector, etc. were proposed for color feature descriptor.

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http://dx.doi.org/10.1016/j.neucom.2015.03.015
0925-2312/

Gray level co-occurrence matrix (GLCM) first introduced by Haralick, and it is a very popular method for extracting statistical features of the image [1]. GLCM is a matrix, that depends on the co-occurrence of every two pixels in image. Haralick calculated the statistical features of GLCM for texture feature extraction. GLCM was applied directly to the image to calculate the features, but Zhang et al. used edge image to extract more precise information using GLCM in texture images [2]. They applied the Prewitt edge detector in four directions and calculated GLCM of edge images, and used statistical features of co-occurrence matrices for texture image retrieval. GLCM was extended to single and multi-channel co-occurrence matrix for RGB and LUV color channels, and applied for color texture image retrieval [3]. Partio et al. used gray level co-occurrence matrix with statistical features for rock texture image retrieval [4]. Gaussian smoothing and pyramid representation were utilized for extracting multi-scale images, and GLCM is applied to the obtained multi-scale images, and statistical features were calculated for image retrieval by Siqueira et al. [5]. Further, GLCM was broadly used for different applications [6–8].

Swain and Ballard presented the idea of color histogram, and distance measure for image matching via histograms [9]. Two new schemes were presented by Stricker and Orengo for color indexing in that, first holds complete color distribution, and second contains only major features instead of the full distribution [10]. For both color and texture information, standard wavelet transform and Gabor wavelet transform were combined with color histogram and applied for image retrieval [11]. Further, new color feature has been proposed using co-occurrence and clustering. Lin et al. proposed three features, that are color co-occurrence matrix (CCM), difference between pixels of scan pattern (DBPSP) and color histogram for K-mean (CHKM), in which CCM and DBPSP are related to color and texture, and CHKM corresponds to the color feature [12]. Integrated color and intensity co-occurrence matrix has been proposed for color and texture features. Composition of color and texture features has been computed in it rather than separation. Instead of RGB, HSV color space is used for color representation, and this method is applied for image retrieval in large, labeled and unlabeled image database [13]. Color histogram considers the frequency of each intensity but it does not handle the spatial co-relation of colors. Color correlogram was proposed that consider the spatial co-relation of color intensity in the image [14]. Again, color correlogram was used for feature vector, and also a relevance feedback technique has been applied for supervised learning in two ways, first is improving the query image, and second is learning the distance metric, and applied for improved result in image retrieval [15]. Color coherence vector was introduced for image retrieval which uses coherence and incoherence of image pixel colors, and compared with color histogram for image retrieval [16]. Park et al. applied artificial neural network technique for image clustering for fast image retrieval [17]. Gaussian mixture vector quantization (GMVQ) was utilized for better quantization of color histogram for image retrieval [18]. The motif co-occurrence matrix has been proposed for image retrieval, which constructs a 3D matrix, that corresponds to local statistics of image [19]. Murala et al. proposed a method called modified color motif co-occurrence matrix (MCMCM) for image retrieval, which is an extension of the motif co-occurrence matrix that used relationships between color channels [20]. Again, motif matrix was used with texton histogram using HSV color space in [21].

Ojala et al. presented local binary patterns (LBP), which proved its excellence and standard in many areas as a feature descriptor [22]. Local binary pattern was modified into uniform and rotation invariant local binary pattern [23]. Translation, rotation and scale invariant method using color and edge has been proposed for color–texture and natural image retrieval [24]. LBP compares all neighboring pixels with center pixel, but Heikkilä et al. presented

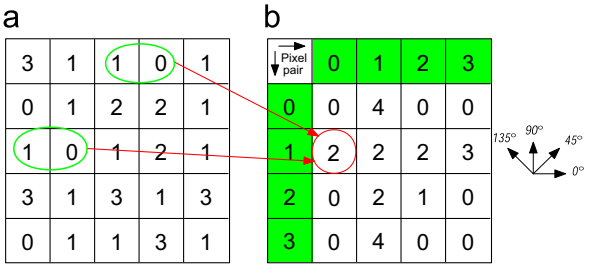

Fig. 1. Gray level co-occurrence matrix calculation example. (For interpretation of the references to color in this figure caption, the reader is referred to the web version of this paper.)

center-symmetric local binary patterns which computes the difference in four directions [25]. Tan and Triggs proposed local ternary pattern (LTP) that compares neighboring pixels and center pixel with a threshold interval, and assign a ternary pattern (1, 0, −1). Further, it is converted into two binary patterns (0, 1), and this method is applied to face recognition [26]. LBP and LTP were based on all neighboring pixels evenly. A direction based method called directional local extrema pattern (DLEP) has been proposed for directional edge information in 0°, 45°, 90° and 135° directions, and applied for image retrieval [27]. Local extrema pattern has been proposed by Murala et al., and joint histogram of color and LEP has been applied for object tracking [28]. Multi-resolution local extrema patterns have been proposed, in which LEP has been obtained from wavelet domain instead of original images [29]. Moment based local binary pattern has been proposed, in which LBP has been derived from momentgrams, and momentgrams have been constructed from moment invariants of original image [30]. Zhang et al. proposed local derivative pattern (LDP) [31], that is a higher order local binary pattern, and applied it for face recognition. Local ternary co-occurrence patterns (LTCoP) have been proposed for medical image retrieval, that utilize the properties of LTP and LDP [32]. A method based on edge distribution using local pattern was proposed, and called local maximum edge binary pattern (LMEBP). It was obtained by considering the magnitude of local difference between the center pixel and reference eight neighborhood pixels in descending order, and LMEBP was obtained for all eight neighbor pixels. LMEBP was applied for image retrieval and object tracking [33]. Further, LMEBP is extended by Jasmine and Kumar [34], in which only first three uniform and rotational invariant LMEBPs were considered as feature vector, also an HSV color histogram was used for feature vector, and finally joint histogram was constructed for image retrieval. After local binary pattern and local ternary pattern, Murala et al. proposed local tetra patterns which took advantage of vertical and horizontal directional neighborhoods of each pixel and constructed a tetra pattern, which was again converted into binary patterns [35]. They combined it with Gabor transform, and applied it for image retrieval. Jacob et al. extended local tetra patterns in RGB color channels. For each center pixel of a particular color channel, other color channels were used for horizontal and vertical direction pixels, and applied it for image retrieval [36].

1.3. Main contribution

In this paper, authors have conferred a new method for image retrieval based on color and texture features. Main involvements in the current paper are as follows:

1. A new feature descriptor local extrema co-occurrence pattern (LECoP) has been proposed.

Please cite this article as: M. Verma, et al., Local extrema co-occurrence pattern for color and texture image retrieval, Neurocomputing (2015), http://dx.doi.org/10.1016/j.neucom.2015.03.015